



Optimal Corn Grain Feeding in Wisconsin Dairy Diets

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Diminishing milk production to corn grain

There is a direct relationship between milk production and corn grain in the diet. In general, more corn grain will result in more milk production. However, this relationship follows the law of "diminishing returns" and consequently the response of milk produced from each additional unit of corn grain has a negative trend. For example 1.2 lb of milk will be produced from the first lb of corn in the diet, but only 0.25 lb of milk from the 22th additional lb of corn (Figure 1).

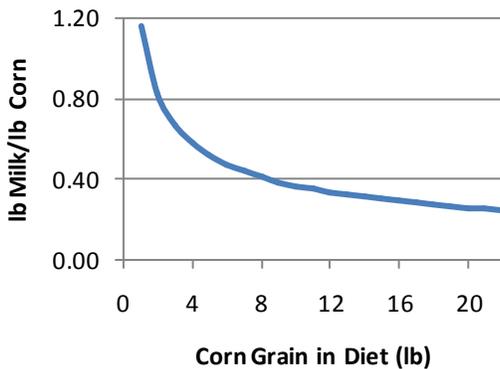


Figure 1. Diminishing milk production from corn grain in week of lactation 20.

Diminishing milk production to lactation stage and corn grain

Milk production with respect to corn grain is also heavily affected by the lactation stage. In general, maximum production of

milk from additional corn grain is achieved in early lactation (1-12 weeks); this decreases in mid-lactation (13-26 weeks), and is minimal in late lactation (27+ weeks). For example, this ratio fluctuates between 2.15 and 0.45 for week of lactation 13, between 0.79 and 0.17 for week of lactation 25, and between 0.34 and 0.07 for week of lactation 36 (Figure 2).

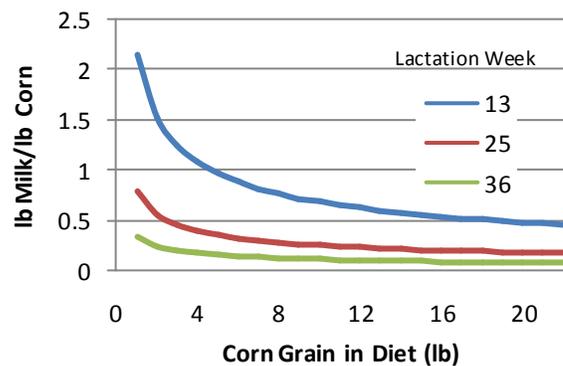


Figure 2. Diminishing milk production based on lactation stage and corn grain in diet.

Optimal utilization of corn grain

The maximum return to corn grain utilization is achieved when the value of an additional unit of corn equals the value of extra milk produced. This is also called the "break-even" point in the production function curve and this may or may not coincide with the maximum milk production level.

With historical low corn grain prices with respect to milk prices, the rationale has predominantly been to maximize milk production by using the maximum



amount of corn grain in the diet, which usually also optimized the net return. Nowadays, skyrocketing corn prices, and more importantly, a substantial decrease in the ratio of price of milk vs. price of corn, demands revisiting the concept of maximum net return from additional use of corn grain.

For example, in December 2000, the milk price was \$13/cwt (\$0.13/lb) while the corn price was \$2/bu (\$0.035/lb). Consequently the milk/corn ratio was 3.7. Therefore, corn utilization was justified even if the return to any additional unit of corn was only $1/3.7=0.27$ lb of milk.

In June 2008, milk price was \$19.40/cwt (\$0.194/lb) while the corn price was \$6.12/bu (\$0.11/lb). Consequently, the milk/corn ratio was 1.76. Therefore, corn utilization would only be justified if the milk production from an additional unit of corn is equal or greater than $1/1.76=0.57$ lb of milk.

In other words, in December 2000 the value of a lb of corn equaled the value of 0.27 lb of milk, whereas in June the value of corn equaled to 0.56 lb of milk. This is a 2.07 times relative increase.

The optimal economic level of corn utilization needs to be revisited. This is especially important in situations when the additional milk production of additional corn utilization approaches the corn/milk price ratio. According to Figure

2 for example, with July 2008 prices, corn should not be used in lactation week 25 or later, it should only be used at around 8 lb in week 13. The decision, therefore, is more critical in mid-lactation.

Dynamics of prices and dairy herd management

The business of producing milk is highly dynamic: 1) Prices of corn and milk are constantly changing and may differ substantially from one producer to the next; 2) Cows are always progressing through lactation stages; and 3) the actual amount of corn grain in the diet varies substantially not only among producers, but also inside the same farm operation. These dynamics greatly impact the decision of increasing or decreasing the current amount of corn grain in the diet.

Consequently, farm producers need to make decisions in a dynamic fashion. An interactive tool would help them in this permanent decision-making. The companion spreadsheet ([Corn-to-Milk](#)) to this paper attempts to help producers in these complex decision-making.

Field experimentation data

In order to make these decisions, it is critical to understand the real relationship between additional milk from additional corn grain according to lactation stage and the current level of corn grain in the diet. The most comprehensive field



research in this subject area in Wisconsin was developed by Tessmann et al. (1991) that studied the response of 90+ cows to 5 diets (0 to 42% corn grain) for complete lactation periods. The diets used alfalfa silage, high moisture ear corn, and soybean meal in different proportions according to early (1-12 weeks), medium (13 to 26 weeks), and late (27 to 44 weeks) lactation stages. The companion spreadsheet ([Corn-to-Milk](#)) presents the main treatments (diets) used in this study in the sheet entitled "Diets."

Milk production functions

Field research data can be used to generalize results and apply them broadly. Earleywine (2001) used Tessmann et al. (1991) research results to predict milk production curves with various levels of corn grain and other diet components. These prediction curves resemble field experimental data very closely. Consequently, these can be used with confidence to assess the impact of corn grain in milk production. The companion spreadsheet ([Corn-to-Milk](#)) presents estimates of DMI, corn grain in diet, and milk production by using Earleywine (2001) production functions.

Income over feed cost (IOFC)

The income over feed cost (IOFC), using May 2008 prices of milk at \$18.2 /cwt, alfalfa hay at \$177/ton, corn grain at \$5.12/bu, and soybean meal at \$350/ton

shows greater differences in early lactation and only minimal differences in late lactation among diets. Diet 1 (42-25% corn grain) would produce the maximum milk quantity, maximum revenue, and the greatest IOFC. Diet 5 (0% corn grain) would have the lowest IOFC. However, if the price of corn grain is changed to \$7.55 as for July 2008 (Figure 3), the IOFC would be eventually identical for diets 1, 2 (34-17% corn grain), and 3 (27 to 9% corn grain) in mid and late lactation.

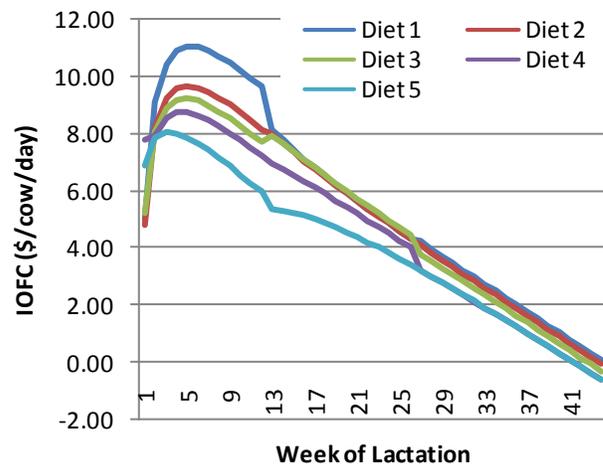


Figure 3. Income over feed cost (IOFC) for different corn grain diets and weeks of lactation. May prices of milk, alfalfa hay, and soybean meal. July price of corn grain at \$7.55/bu.

The companion spreadsheet ([Corn-to-Milk](#), sheet "IOFC") calculates the feed cost, the overall milk revenue, and the IOFC for input user-defined prices of milk, alfalfa hay, corn grain, and soybean meal.



Marginal production of milk from additional corn grain

Using the derivative of the milk production function with respect to corn grain in the diet, it is possible to assess the marginal response of milk production to marginal changes of corn grain in the diet. These curves indicate how much more milk is produced by each additional unit of corn (Figure 4).

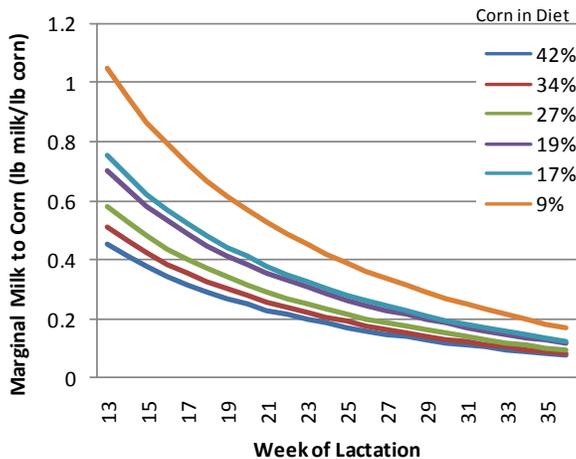


Figure 4. Marginal milk production for different levels of corn in the diet and weeks of lactation.

Diets with a low content of corn (9%) will have a greater response than diets with high content of corn (42%).

Similarly, production functions have been used to predict the marginal milk production by week of lactation (Figure 5). Cows in mid lactation (week 13) will have a greater response than cows in late lactation (week 36).

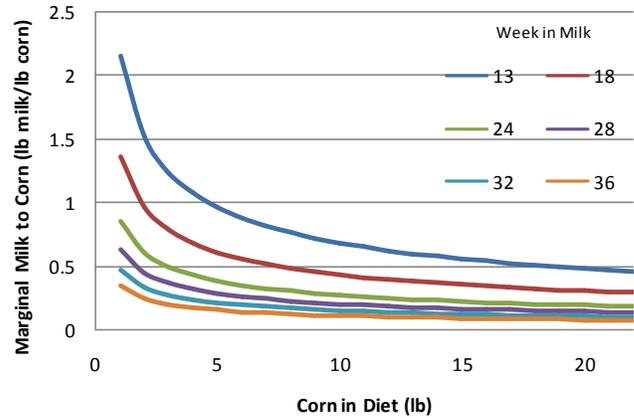


Figure 5. Marginal milk production for different lactation stages.

Marginal value of milk to corn and optimization of corn in the diet

The marginal production curves together with the relative price of milk to price of corn are used to find the optimal amount of corn in the diet according to lactation stage in the companion spreadsheet [Corn-to-Milk](#), sheet "MarginalValues."

Using May 2007 prices of milk of \$18.2/cwt (\$0.182/lb) and corn of \$5.12/bu (\$0.09143/lb) it is possible to calculate the marginal value of additional milk produced by each additional unit of corn. As previously stated, corn will be used as long as the marginal value is greater or equal to 1. The marginal value analysis indicate that additional corn could still be used in diets containing 27% or lower corn (Figure 6). However, this marginal value will decrease with weeks of lactation. For example, additional use of



corn could be justified for diets with 9% of corn, but only until week of lactation 23.

marginal value does not justify the inclusion of corn in the diet.

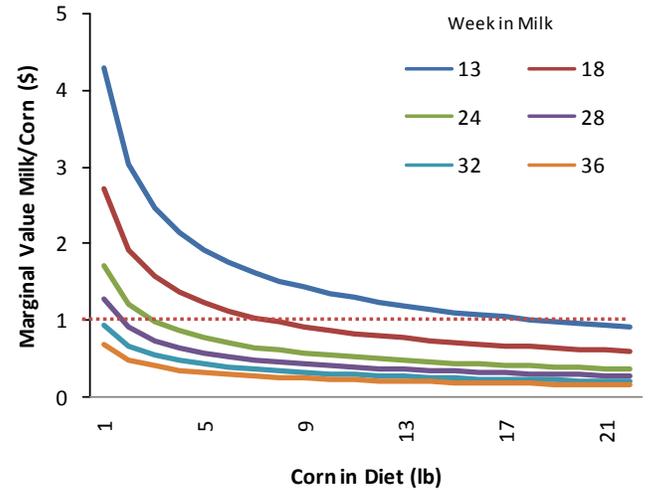
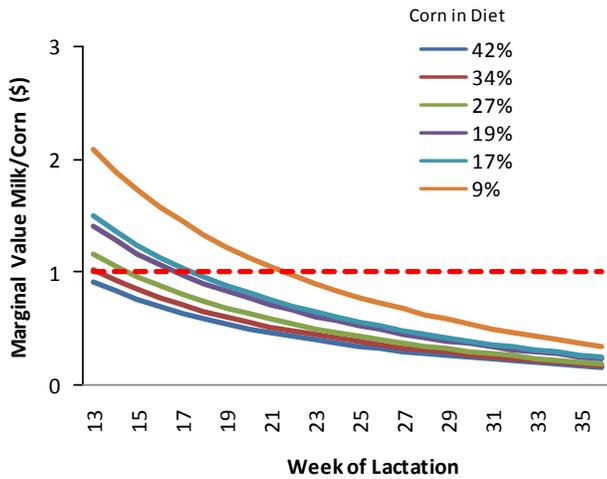


Figure 6. Marginal value of milk to corn when milk price is \$18.2/cwt and corn price is \$5.12/bu.

Figure 7. Marginal value of milk to corn when milk price is \$18.2/cwt and corn price is \$5.12/bu.

In the same fashion, it is possible to estimate the marginal value of corn to milk production by incremental units of corn (lb of corn) and weeks of lactation. Figure 7 shows the marginal value of milk to corn for the same prices. As in the previous case, the optimal level of corn utilization is the break-even point when the marginal value of milk equals the marginal value of corn, which is denoted with a dotted line in the figure. For May prices of corn and milk, it is worth using up to 17 lb of corn, if a cow or a group of cows are in week of lactation 13. This optimal level changes to 8 lb of corn for cows in week of lactation 18 and to 3 lb of corn for cows in week of lactation 24. For cows in week of lactation 32 and over, the

What to do when prices change?

The companion spreadsheet (Milk-to-Corn) is an interactive tool that redraw these curves when prices change. Prices can be changed in yellow highlighted cells. A logical current question is how this analysis and the potential decisions are going to change with a price of corn of \$10/bu, if the milk price remains at \$18.20/cwt?

With a \$10/bu corn price the opportunity of corn use would decrease substantially in mid and late lactation (Figure 8). For \$10/bu corn, only diets with less than 9% corn could economically use more corn and only until week 14. Indeed, diets with more than 9% content of corn, will not pay for additional corn after week of



lactation 13. For example, in week of lactation 15, the monetary return of \$1 invested in corn would only be \$0.38 when the diet contains 42% of corn (Figure 8A).

For \$10/bu corn, after week of lactation 12, it would be justified to decrease the current amount of corn in most of the cases.

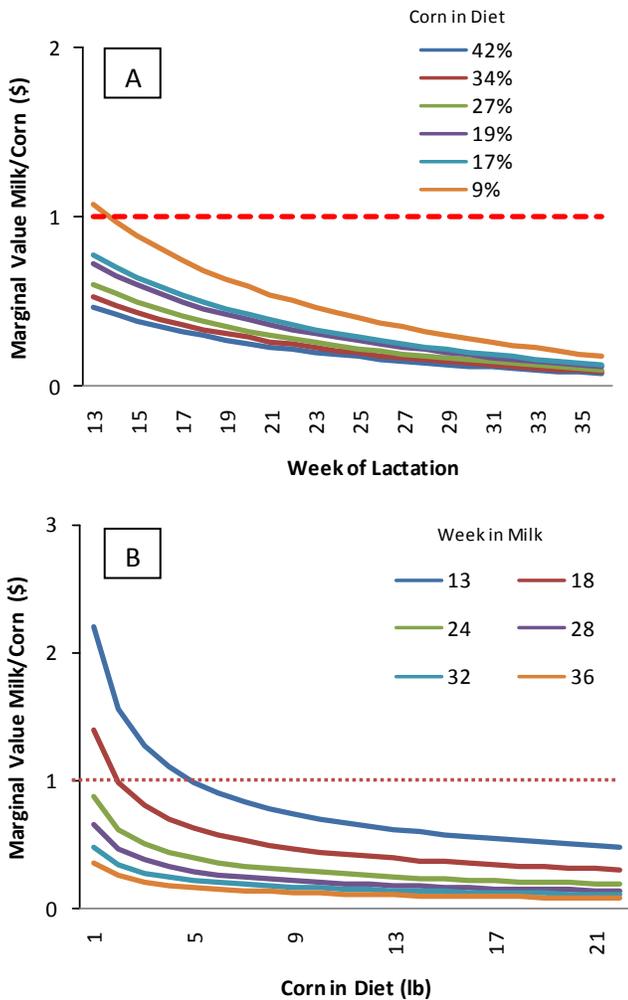


Figure 7. Marginal value of milk to corn when milk price is \$18.2/cwt and corn price is \$10/bu.

For \$10/bu corn, more corn could only be justified if the current usage is less than 5 lb in week of lactation 13 or less than 2 lb in week of lactation 18 (Figure 8B).

Herd structure and modeling. Diets are formulated for group of cows rather than individual cows and consequently it is not realistic to assume that the optimal grain diet would always be applicable to all cows in a group. A herd simulation model has also been included in the companion spreadsheet [Corn-to-Milk](#), sheet "HerdGroups." The herd model estimates the number of cows in each week of lactation (1 to 44) according to input herd size and culling rate. This sheet also finds the diet that maximizes the IOFC (optimal IOFC) in each one of 44 weeks of lactation. Finally, it calculates the overall IOFC for different herd grouping strategies. For example, for a milk price of \$18/cwt, alfalfa hay at \$177/ton, corn at \$7/bu, and soybean meal at \$350/ton the optimal diet grouping would be: week 1: Diet 4, week 2-20: Diet 1, week 21-25: Diet 3, and week 26-44; Diet 1. The spreadsheet calculates the overall IOFC for a week of production when having only one diet to all groups (\$2,808) or the optimal diet for each group (\$3,524). By default, it assigns the optimal diet of the first week-group to all weeks in the group. It displays groups between 1 (same diet of week 1 to all weeks) and 44 (each week uses its own optimal diet), consequently



these groups should be used as indicators rather than recommendations.

Where can I find the spreadsheet Corn-to-Milk?

It is available from the UW-Madison Dairy Management website at:

<http://www.uwex.edu/ces/dairymgt/>

under the heading Management Tools.

Limitations of analysis and further work

Body score. The present analysis does not consider potentials for reductions in loss of body conditions for cows fed with low grain diets. Body score at dry off may decrease from 3.7 to 3.5 and to 2.9 for high, moderate, and low grain diets, respectively (Tessmann et al., 1991). There are also evidences that low grain diets may decrease glucose and increase BHBA (b -hydroxybutyrate) in cow's blood (Dhiman et al., 1991), which may suggest increased risk of ketosis.

Next lactation productivity. Low grain diets could decrease future lactation milk production between 18 and 15% compared with moderate and high corn grain diets (Tessmann et al., 1991). This relationship has been ignored in this analysis that only considers present lactation. However, it would be important to incorporate this effect in future work.

Milk productivity. Results from Tessmann et al. (1991) are comparable with today's Wisconsin average cows that produce between 19,000 and 20,000 lb/cow/year (NASS, 2007). However, today, there are many high producing herds in Wisconsin including top herds with more than 30,000 lb milk/cow/year. For those high producing herds, the analysis would not be appropriated. Further work in this area is under development.

Acknowledgements

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